Systematic errors from pixelization

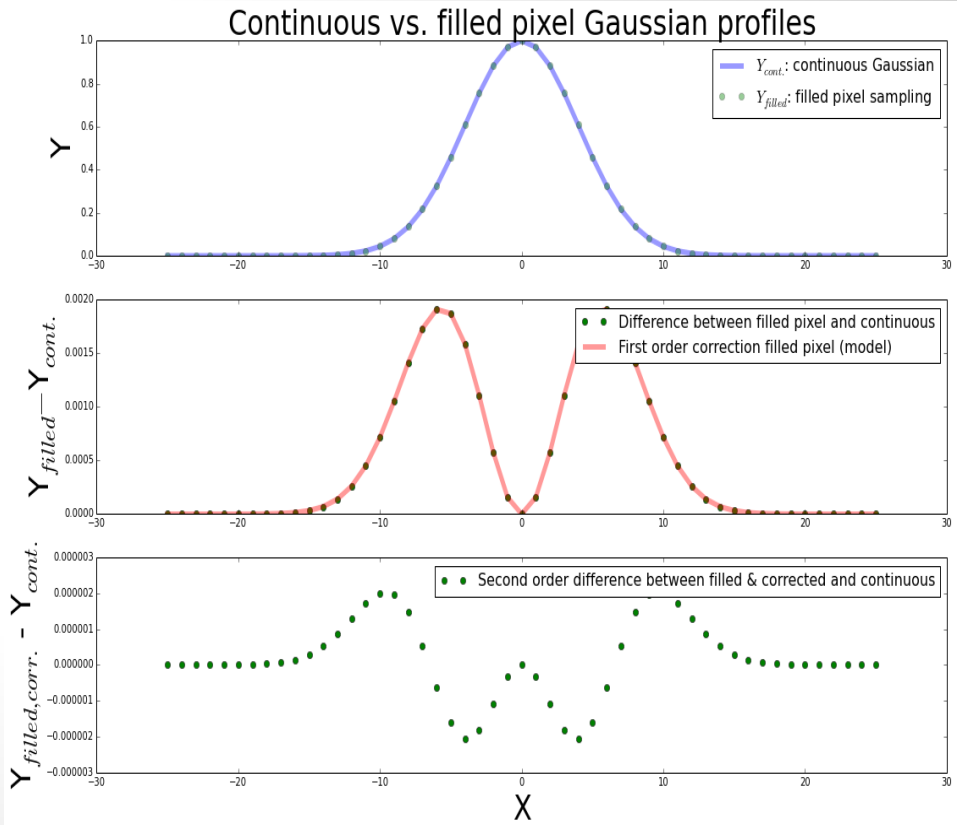
Andrew Bradshaw
UCD

introduction

- Pixels of course, are not point-like detectors, but have characteristic width (among other properties)
- Incorrect model of pixel → systematic error, large enough that it needs to be considered for precision cosmology

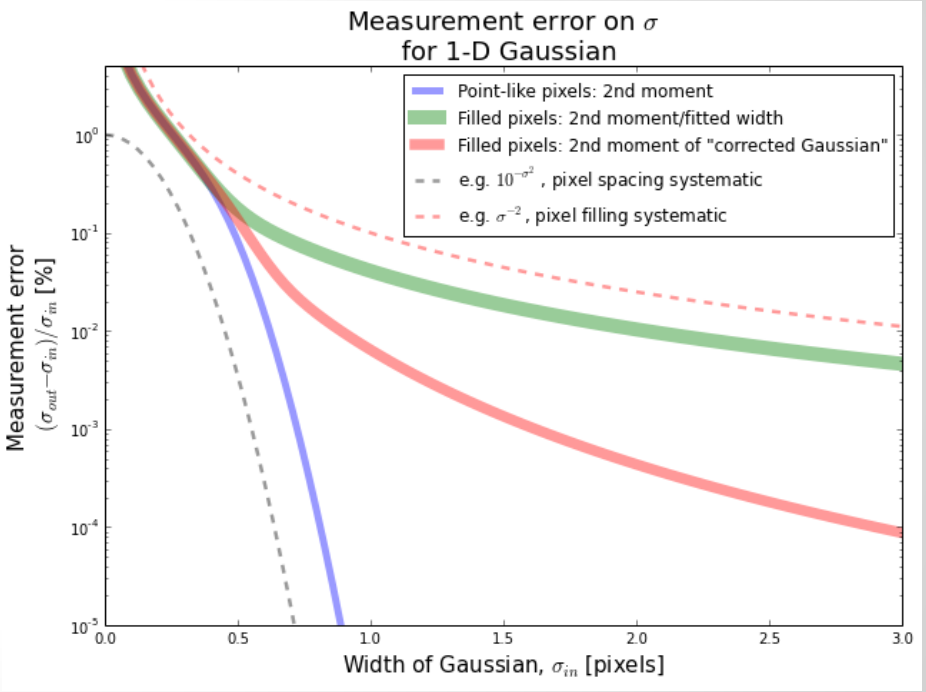
simple example: size bias in fitting pixelized gaussian image

- Take continuous Gaussian g(x) and sample it at points x_i to get image $i(x_i)$
  - small-scale information lost
  - point-like pix: $i=\int g(x)*\delta(x-x_i)$
  - filled pix: $i=\int g(x)*\mathrm{rect}(x-x_i)$
- Difference between input continuous and “filled pixel” image is small but significant
  - can be modeled by integrating terms of Taylor series of Gaussian



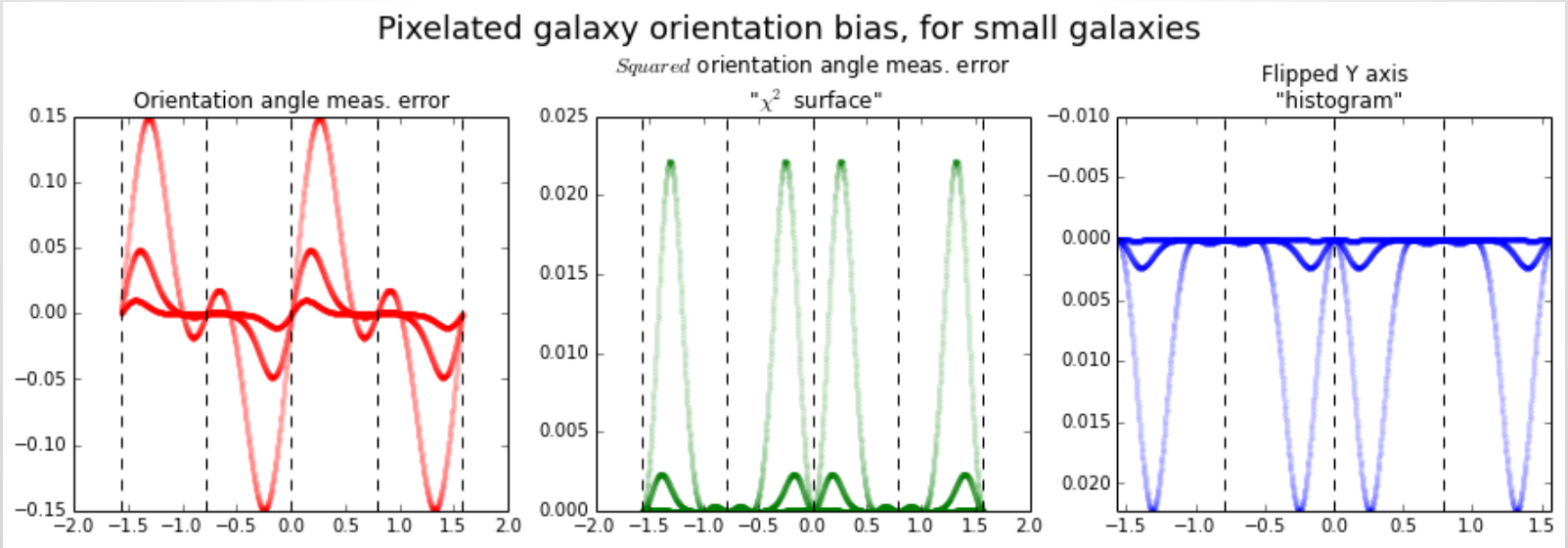
simple example: continued

- Measuring the 2nd moment (or fitting a continuous Gaussian) to the pixelized image results in overestimate of width
  - Overestimates even if correction for pixelization “filling up” is taken into account
- Two types of errors here, 1) not accounting for “filling up” and 2) undersampling due to pixel spacing

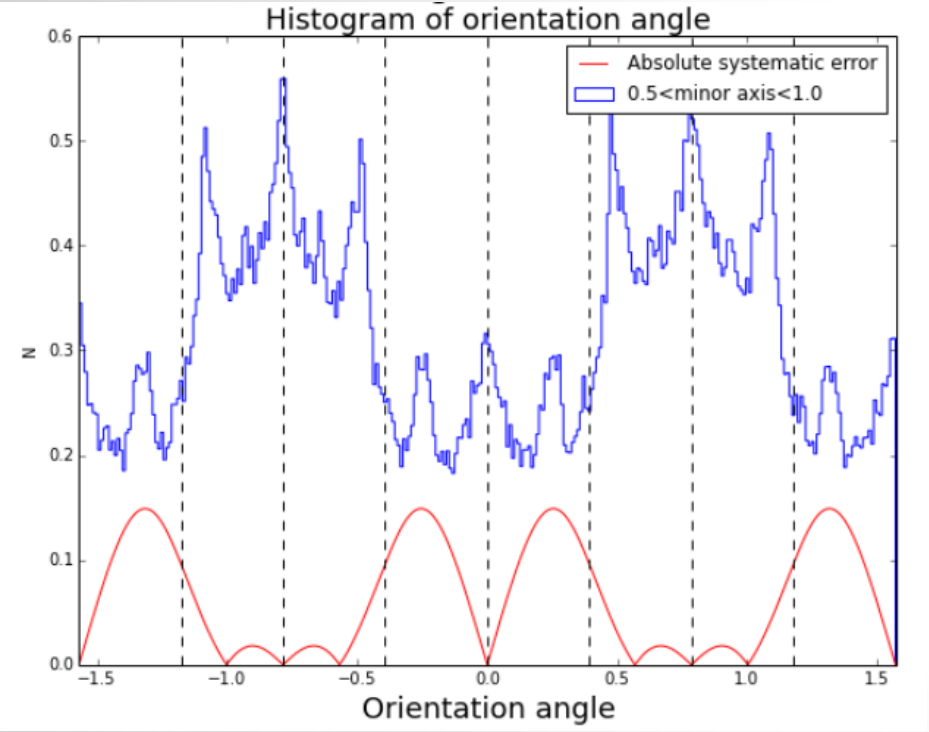


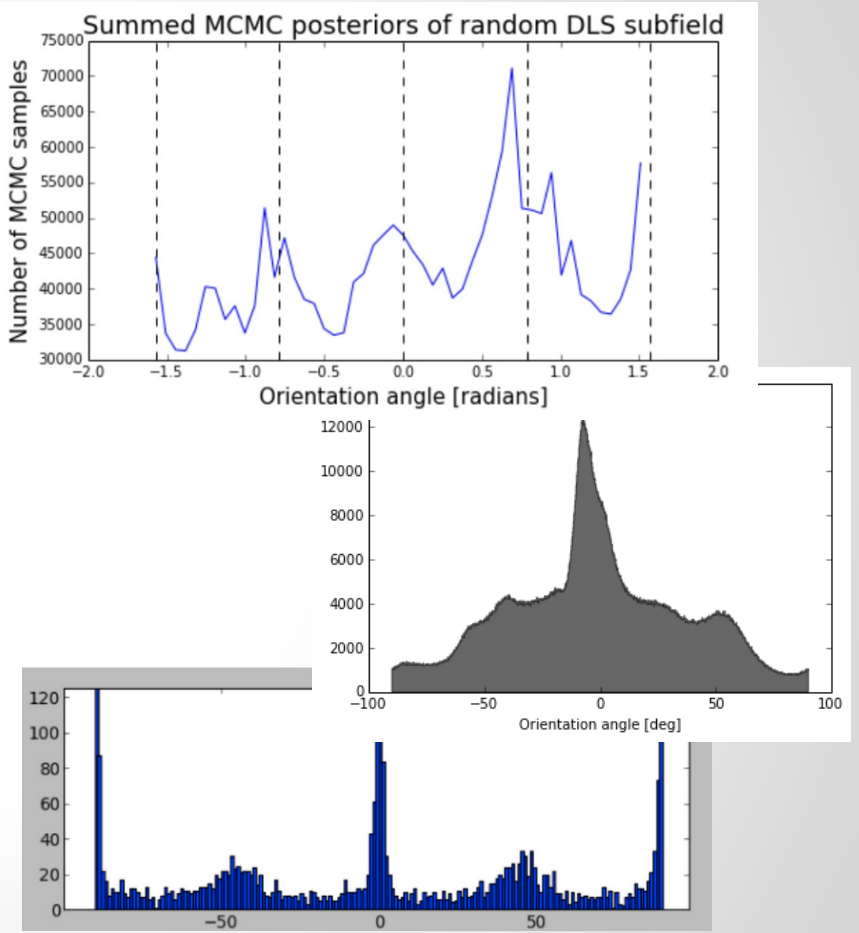
size bias can lead to orientation bias in 2D

- As an elliptical Gaussian is rotated through the pixel plane, the X & Y 2nd moments change
- Changing input X&Y moments changes systematic error level
- Simple least-squares minimizer will find systematic error minima → orientation preference
- orientation bias is sourced from any size measurement bias



evidence of orienta





...lots more

need to model the pixel

not only must the pixel's width be taken into account, but other systematics too: ccd edge effects, astrometric residuals, charge spreading, backside bias of chip

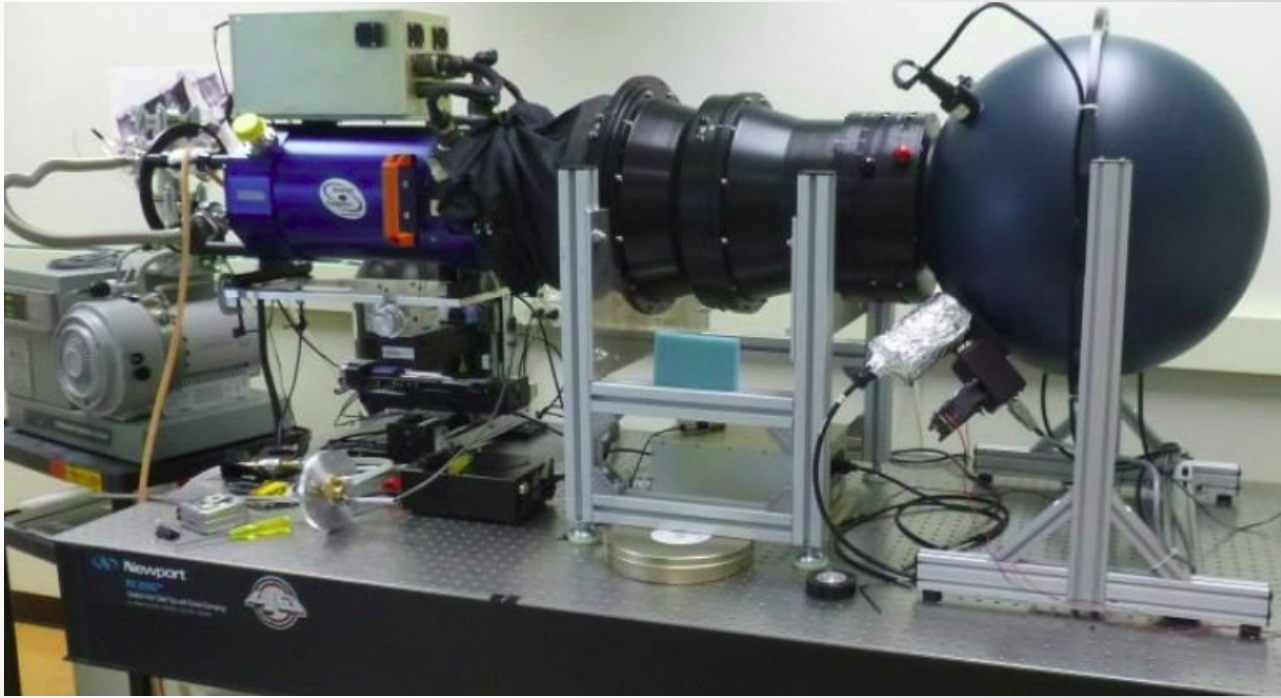
a full model of pixel is necessary for precision science, lots of work to do!

facility for testing

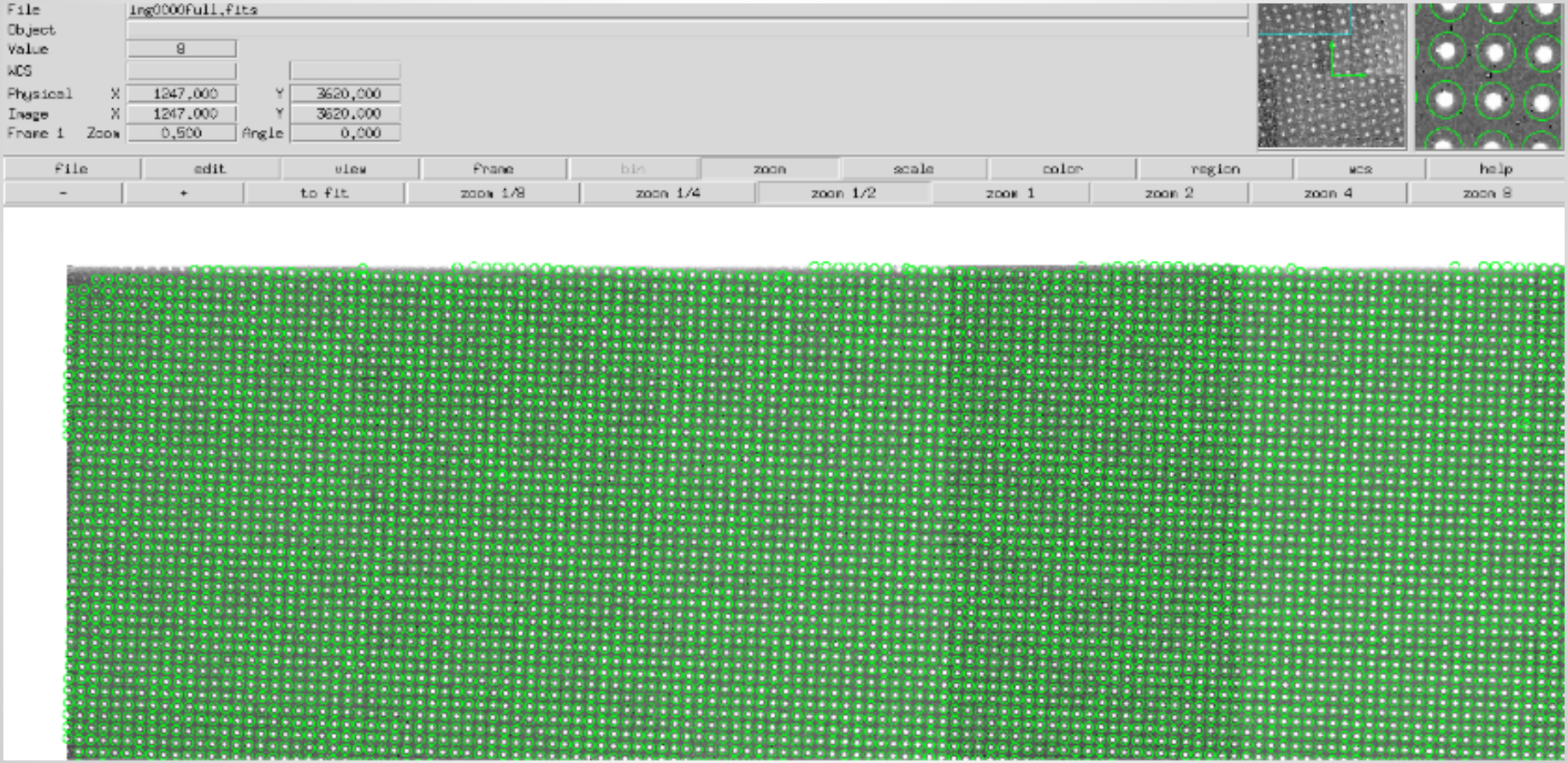
f\1.2 reimager with precision control over

- XYZ pos. ~1um
- flux of light to 1%
- filter, integration time, backside bias, etc.

Use this as a pixel modeler



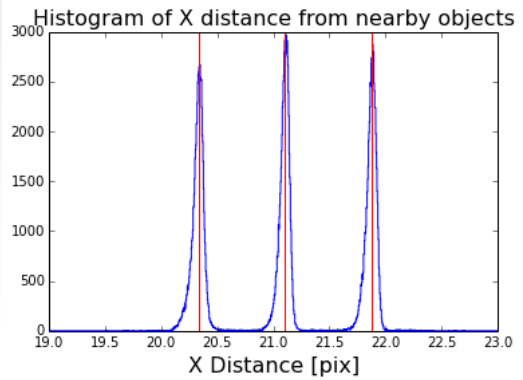
40,000 pinholes per exposure x hundreds of exposures= millions of data points in one run

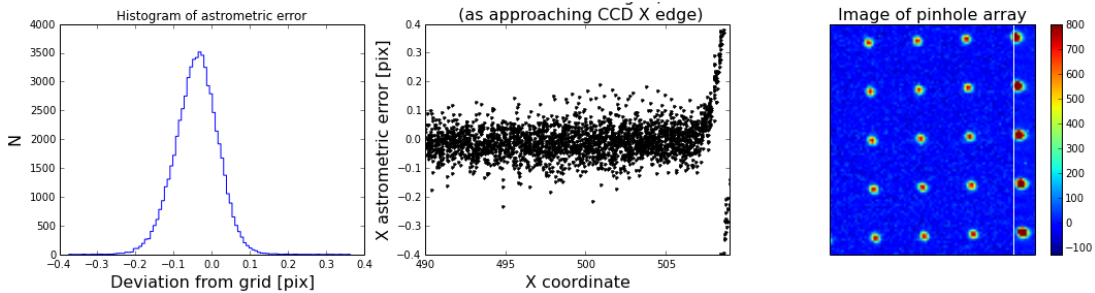


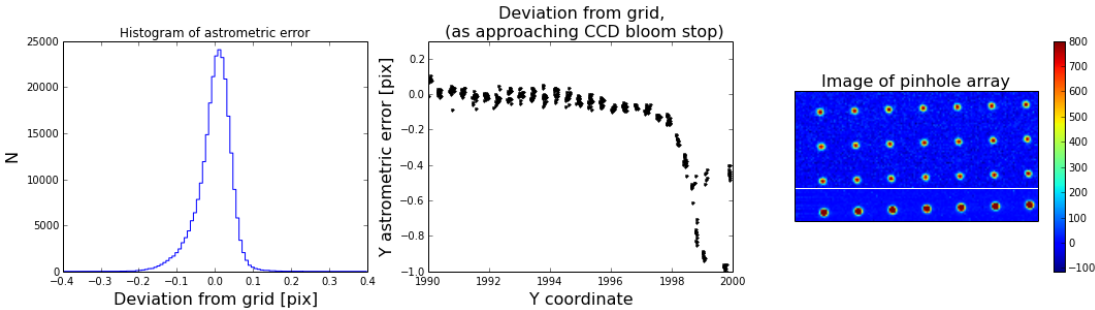
edge effects

- use pinhole grid in each image to define local coordinate system independent of CCD, calculate “astrometric residual”
  - deviation from local astrometric system at edges
- Other methods...

subpixel precision on local astrometry

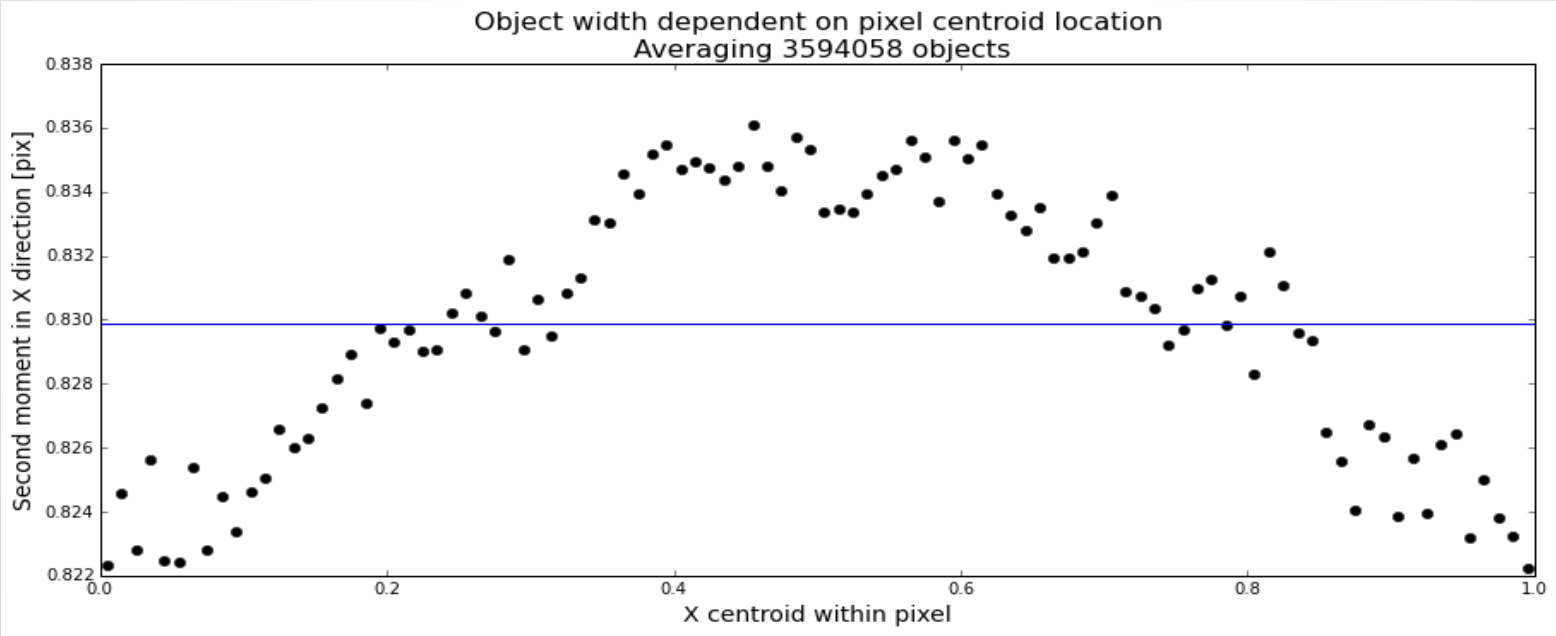






pixel centroid effect

- used sextractor centroids and widths to test if width is dependent upon location within pixel
  - model error or physics within pixel?



questions, comments, ideas?